

## Three Newly Recorded Species of the Family Mesorhabditidae (Nematoda: Rhabditida) in South Korea

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### ABSTRACT

The family Mesorhabditidae Andrassy, 1976 is the most abundant group in Rhabditoidea and occurs all over the world. Over 85 valid species have been reported from Mesorhabditidae; however, only 2 species have been recorded in South Korea. In this study, *Bursilla vernalis* Andrassy, 1982, *Mesorhabditis inarimensis* (Meyl, 1953) Dougherty, 1955, and *M. minuta* Boström, 1991 belonging to the family Mesorhabditidae (Rhabditomorpha), are newly reported from South Korea. Species in this family are distinguished from other rhabditomorphs by a posteriorly located vulva and an unpaired prevulval female gonad. Details of the morphological characters and morphometrics of *B. vernalis*, *M. inarimensis*, and *M. minuta* are described and illustrated based on optical and/or scanning electron microscopy.

**Keywords:** Mesorhabditidae, *Bursilla*, *Mesorhabditis*, SEM, new record

### INTRODUCTION

The family Mesorhabditidae Andrassy, 1976, which consists mostly of deposit- or detritus-feeders, is found in nearly all terrestrial habitats (soil, compost, plant, and animal residues), with a small percentage found in water (hot springs) (Meyl, 1953, 1954; Dassonville and Heyns, 1984; Zeidan and Ger-aert, 1989). Almost all mesorhabditid nematodes are free-living soil forms except for the genus *Parasitorhabditis*, which is made up of insect semi-parasitic or parasitic species (Andrassy, 2005). The family Mesorhabditidae is in the infraorder Rhabditomorpha and is part of the superfamily Rhabditoidea, which includes four family groups of free-living nematodes (the other families are Diploscapteridae Micoletzky, 1922, Peloderidae Andrassy, 1976, and Rhabditidae Örley, 1880) (see De Ley and Blaxter, 2004). Morphologically, mesorhabditids are distinguished from other rhabditomorphs by a posteriorly located vulva and an unpaired prevulval female gonad. To date, 11 genera and over 85 valid species have been described (Andrassy, 2005). In Korea, 2 species belonging to 2 genera have been previously reported (Lee et al., 1990; Tahseen et al., 2009): *Distolabrellus veechi* Anderson, 1983, and *Parasitorhabditis hylurgi* Massey, 1974.

During a survey of some plots of natural forest, overgrown fields and strawberry farmland, *Bursilla vernalis* Andrassy,

1982, *Mesorhabditis inarimensis* (Meyl, 1953) Dougherty, 1955, and *M. minuta* Boström, 1991 were collected and isolated from soil samples. Here, we provide detailed descriptions of the morphological characters and morphometrics of the Korean isolates of *B. vernalis*, *M. inarimensis*, and *M. minuta*.

### MATERIALS AND METHODS

#### Nematode isolation

Soil samples were collected from natural forest soil (Geojesi, Gyeongsangnam-do, South Korea [GPS coordinates: 34°47'04.2"N, 128°37'30.3"E]), overgrown fields (Ansan-si, Gyeonggi-do, South Korea [GPS coordinates: 37°12'02.9"N, 126°32'24.6"E]), and a strawberry farm (Nonsan-si, Chungcheongnam-do, South Korea [GPS coordinates: 36°09'10.9"N, 127°06'55.7"E]). Nematode specimens were extracted by sieving and the Baermann funnel method (Baermann, 1917).

#### Fixation and morphological observations

For observations and morphometrics, each nematode specimen was transferred to 2 mL of water in a 15 mL tube, to which was quickly added 4 mL of 80°C TAF (2% triethanolamine and 7% formaldehyde) for fixation. The fixed nema-

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todes were processed to dehydrated glycerin as described by Seinhorst (1959) and mounted in pure glycerin on permanent HS-slides (Shirayama et al., 1993). Nematode morphological characters were observed under an optical microscope (BX-51; Olympus, Tokyo, Japan) equipped with differential interference contrast, and morphometric characters were measured using a CoolSnap Photometrics color CCD digital camera (MP5.0-RTV-R-CLR-10; Photometrics, Tucson, AZ, USA) and the program QCapture Pro 5 (QImaging, Surrey, Canada).

### Scanning electron microscopy

For scanning electron microscopy (SEM) imaging, the *M. minuta* specimens fixed using TAF were transferred to a 4% aqueous osmium tetroxide solution and kept at 4°C for 1 day for post-fixation. Fixed nematode specimens were dehydrated through a series of 10–100% absolute ethanol (1 h per stage). The samples were dried using a Hitachi HCP-2 critical point drier (Tokyo, Japan). Dried nematodes were mounted on copper/nickel tape attached to a stub and sputter coated with gold/palladium using an Eiko IB-3 ion coater (Tokyo, Japan). Morphological characters of the nematode specimens were observed with a Zeiss Ultra Plus SEM (Oberkochen, Germany) at 15 kV under high-vacuum conditions.

## SYSTEMATIC ACCOUNTS

Order Rhabditida Chitwood, 1993

Suborder Rhabditina Chitwood, 1993

Infraorder Rhabditomorpha De Ley and Blaxter, 2002

<sup>1\*</sup>Superfamily Mesorhabditoidea Andrassy, 1976

<sup>2\*</sup>Family Mesorhabditidae Andrassy, 1976

<sup>3\*</sup>Genus *Bursilla* Andrassy, 1976

<sup>4\*</sup>***Bursilla vernalis* Andrassy, 1982 (Table 1, Fig. 1)**

**Material examined.** 1♀ and 1♂, South Korea: Gyeongsangnam-do, Geoje-si, Dongbu-myeon, Geojejungang-ro, 5 Jul 2017, extracted by sieving and the Baermann funnel method from natural forest soil. The two specimens (slide Nos. NIBRIV0000326010 [female] and NIBRIV0000326011 [male]) are deposited at the National Institute of Biological Resources, Republic of Korea.

**Measurements.** See Table 1.

**Description. Female:** Body length 483.5 µm long, slightly curved ventrad or straight after fixation (Fig. 1A). Cuticle annulated; annuli 1.4 µm wide and 0.8 µm thick at mid-body.

Lateral field with five incisures, occupying 20.8% of width of body at mid-body, fading out at phasmid region (Fig. 1B). Lip region offset, 8.7 µm in diameter; six rounded lips each ending in a setiform papilla. Transversal, oval-shaped amphidial apertures present. Stoma typical of the group, 1.8 lip region diameter long. Cheilostom short, with weak rhabdia. Gymnostom-promesostegostome tubiform; metastegostome bearing well developed glottoid apparatus. Pharynx typical of the group. Corpus 1.6 times isthmus length; procorpus cylindrical; metacorpus swollen. Isthmus narrower than corpus. Basal bulb ovoid, with well-developed valves; 1.4 times as long as its width. Cardia conoid, surrounded by intestinal tissue. Nerve ring located at isthmus, at 65.2% of pharynx length. Excretory pore position at isthmus-basal bulb junction, at 77.9% of pharynx length. Deirids inconspicuous under light microscope. Reproductive system monodelphic-prodelphic (Fig. 1C). Vagina 0.3 times as long as body diameter. Post-uterine sac absent. Uterus length 1.9 times body diameter. Ovary directed posteriorly, without flexures. Rectum 1.7 times the length of the anal body diameter (Fig. 1D). Tail elongated conoid, with pointed terminus. Phasmids located in anus region.

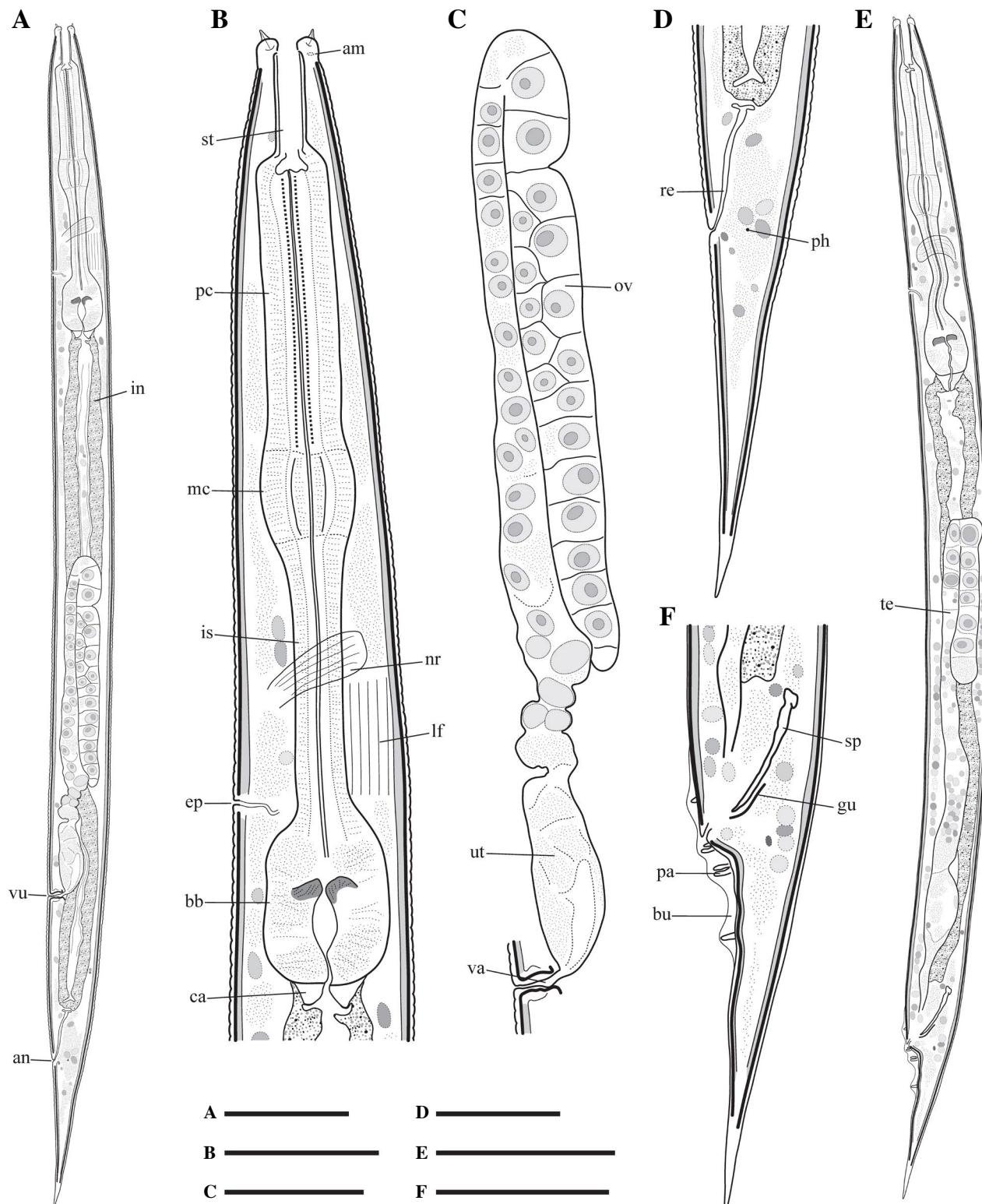
**Male:** General morphology similar to female. Body length 335.6 µm long (Fig. 1E). Cuticle annuli 1.0 µm wide and 0.7 µm thick at mid-body. Lip region 6.4 µm in diameter. Stoma 2.2 lip region diameter long. Corpus 1.4 times isthmus length. Nerve ring located at 64.1% of pharynx length. Excretory pore position at 78.3% of pharynx length. Genital system monorchic. Testis reflexed dorsad anteriorly. Spicules fused distally, 17.9 µm long, one times anal body diameter; manubrium rounded; calamus narrower than manubrium; lamina thin (Fig. 1F). Gubernaculum thin, inconspicuous under light microscope. Tail elongated conical, with pointed terminus. Bursa strongly reduced, with six (1+2+2+1) pairs of papillae.

**Distribution.** Hungary (Andrassy, 2005), India (Rizvi and Bhandari, 2008), South Korea (this study), Vietnam (Andrassy, 1982).

**Habitat.** Natural forest soil.

**Remarks.** Morphological characters and measurements of the specimens described here generally agree with original description of *B. vernalis*, except for the position of genital papillae in the male tail region (1+2+2+1 vs. 3+1+2) (Andrassy, 1982) (Fig. 1F). Although the genital papillae position of the present specimen differs from *B. vernalis*, intraspecific variation of this character has been reported from many other groups, including mesorhabditids (see Abolafia and Peña-Santiago, 2009).

Korean name: <sup>1\*</sup>사이간선충상과(신칭), <sup>2\*</sup>사이간선충과(신칭), <sup>3\*</sup>짧은날개선충속(신칭), <sup>4\*</sup>봄짧은날개선충(신칭)



**Fig. 1.** *Bursilla vernalis* Andrassy, 1982. A, Entire female; B, Female neck region; C, Female reproductive system; D, Female posterior region; E, Entire male; F, Male posterior region. am, amphid; an, anus; bb, basal bulb; bu, bursa; ca, cardia; ep, excretory pore; gu, gubernaculum; in, intestine; is, isthmus; lf, lateral field; mc, metacorpus; nr, nerve ring; ov, ovary; pa, papilla; pc, procorpus; ph, phasmid; re, rectum; sp, spicule; st, stoma; te, testis; ut, uterus; va, vagina; vu, vulva. Scale bars: A, E=50  $\mu$ m, B-D, F=20  $\mu$ m.

<sup>1\*</sup>Genus *Mesorhabditis* Osche, 1952

<sup>2\*</sup>*Mesorhabditis inarimensis* (Meyl, 1953) Dougherty, 1955 (Table 1, Fig. 2)

*Rhabditis inarimensis*: Meyl, 1953: 76, fig. 1.

*Rhabditis (Mesorhabditis) inarimensis*: Meyl, 1954: 176.

**Material examined.** 2♀♀ and 1♂♂, Korea: Gyeonggi-do, Ansan-si, Danwon-gu, Daenam-ro, Mechuri Island, 22 Sep 2016, extracted by sieving and the Baermann funnel method from an overgrown field. Two specimens (slide Nos. NIBRIV0000812920 [female] and NIBRIV0000812921 [male]) are deposited at the National Institute of Biological Resources, Republic of Korea and one female specimen (slide No. 02010101002) is deposited in the Animal Phylogenomics Laboratory, Ewha Womans University, Republic of Korea.

**Measurements.** See Table 1.

**Description. Female:** Body plump, slightly narrower towards front; slightly curved ventrad or straight after fixation; length 446.5–504.6  $\mu\text{m}$  long (Fig. 2A). Cuticle annulated; annuli 1.5–1.9  $\mu\text{m}$  wide and 0.8–1.0  $\mu\text{m}$  thick at mid-body. Lateral field with seven incisures, occupying 27.5–28.1% of width of body at mid-body, fading out at phasmid region (Fig. 2B). Lip region offset, 7.3–8.6  $\mu\text{m}$  in diameter; six rounded lips each ending in a setiform papilla (Fig. 2C). Transversal, oval-shaped amphidial apertures present. Stoma typical of the group, length 1.7–2.1 times lip region diameter. Cheilostom short, with weak rhabdia. Gymnostom-promesostegostome tubiform; metastegostom bearing well-developed glottoid apparatus; telostegostom with rounded rhabdia. Pharynx typical of the group. Corpus 1.6–1.9 times isthmus length; procorpus cylindrical; metacorpus swollen, ovoid. Isthmus narrower than corpus. Basal bulb ovoid, with well-developed valves; 1.4–1.6 times as long as its width. Cardia conoid, surrounded by intestinal tissue. Nerve ring located at isthmus, at 56.2–68.0% of pharynx length. Excretory pore position at isthmus or basal bulb, at 66.1–82.6% of pharynx length. Deirids inconspicuous under light microscope. Reproductive system monodelphic-prodelphic (Fig. 2D). Vagina length 0.3 times body diameter. Post-uterine sac absent. Uterus length 2.3–3.3 times body diameter. Ovary directed posteriorly, without flexures. Rectum length 1.6–1.7 times anal body diameter (Fig. 2B). Tail elongated conoid, pointed terminus. Phasmids located in anus region, at 1.9–5.4% of tail length.

**Male:** General morphology similar to female. Body length 449.2  $\mu\text{m}$  long (Fig. 2E). Cuticle annuli 1.4  $\mu\text{m}$  wide and 0.8  $\mu\text{m}$  thick at mid-body. Lateral field with two incisures, occupying 11.9% of body diameter at mid-body, fading out at phasmid region. Lip region 6.2  $\mu\text{m}$  in diameter. Stoma

length 2.6 times lip region diameter. Corpus 1.5 times isthmus length. Basal bulb 1.6 times as long as its width. Nerve ring located at 62.7% of pharynx length. Excretory pore position at isthmus, at 69.6% of pharynx length. Genital system monorchic. Testis reflexed dorsad anteriorly. Spicules fused distally, 47.0  $\mu\text{m}$  long, 3.9 times anal body diameter; manubrium rounded; calamus narrower than manubrium; lamina very long and thin, with its posterior part S-shaped (Fig. 2F). Gubernaculum almost half of spicules' length. Tail conical, with pointed terminus. Peloderan bursa with nine (2+1+4+2) pairs of papillae, open anteriorly.

**Distribution.** Bulgaria, Germany, Hungary, Italy, Kyrgyzstan, Moldavia, Russia, Uzbekistan (Andrássy, 2005), South Korea (this study).

**Habitat.** Soil sample taken from an overgrown field.

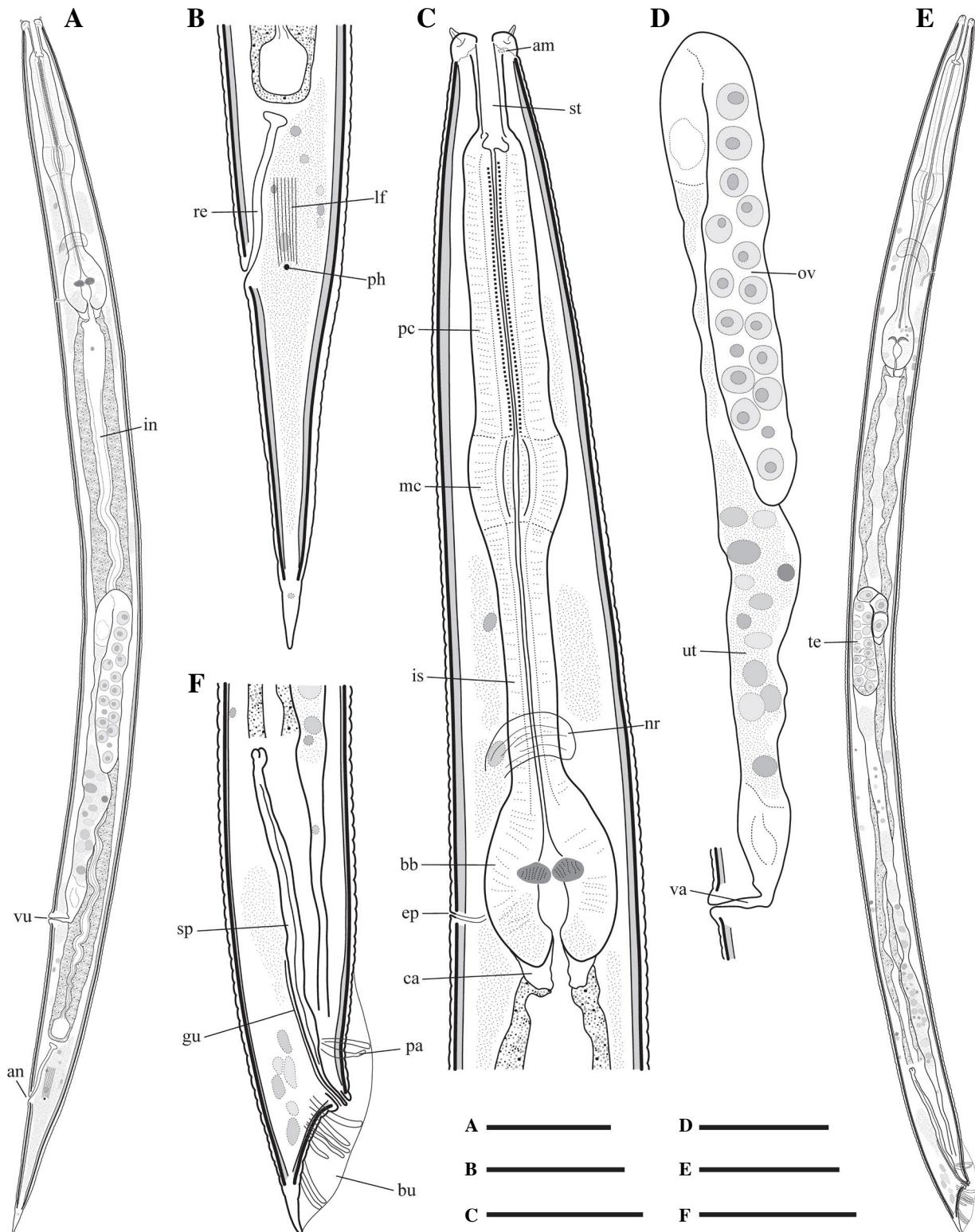
**Remarks.** Morphological characters and measurements of the specimens described here generally agree with descriptions of *M. inarimensis* in previous studies (Meyl, 1953; Sudhaus, 1978; Andrássy, 2005), except for the lips (slightly offset vs. strongly protruding), body thickness ( $a=19.2\text{--}19.3$  vs. 12.3–17.5 in female and 24.8 vs. 14–19.6 in male), vulva position ( $V=72.2\text{--}74.2$  vs. 74.9–85), number and configuration of bursal papillae [nine pairs (2+1+4+2) vs. nine pairs (2+1+3+3) in original description or ten pairs (2+5+3)] and the shape of the posterior part of the spicules (S-shaped and curved vs. U-shaped before distal part) (Fig. 2A, C, E, F). Although the morphological characters listed in the previous sentence differ between the present specimens and *M. inarimensis*, intraspecific variation of these characters has been reported from many other *Mesorhabditis* species, including *M. inarimensis* (Meyl, 1953; Sudhaus, 1978; Andrássy, 2005; Abolafia and Peña-Santiago, 2009).

<sup>3\*</sup>*Mesorhabditis minuta* Boström, 1991 (Table 1, Figs. 3, 4)

**Material examined.** 5♀♀ and 2♂♂, Korea: Chungcheongnam-do, Nonsan-si, Eunjin-myeon, 25 May 2017, extracted by sieving and the Baermann funnel method from strawberry farm soil. Two specimens (slide Nos. NIBRIV0000812918 [female] and NIBRIV0000812919 [male]) are deposited at the National Institute of Biological Resources, Republic of Korea and five specimens (slide Nos. 02010102002–02010101005 [females] and 02010102007 [males]) are deposited in the Animal Phylogenomics Laboratory, Ewha Womans University, Republic of Korea.

**Measurements.** See Table 1.

**Description. Female:** Body length 436.8–696.1  $\mu\text{m}$  long, slightly curved ventrad or straight after fixation (Fig. 3A). Cuticle annulated; annuli 0.7–1.8  $\mu\text{m}$  wide and 0.5–1.3  $\mu\text{m}$



**Fig. 2.** *Mesorhabditis inarimensis* (Meyl, 1953) Dougherty, 1955. A, Entire female; B, Female posterior region; C, Female neck region; D, Female reproductive region; E, Entire male; F, Male posterior region. am, amphid; an, anus; bb, basal bulb; bu, bursa; ca, cardia; ep, excretory pore; gu, gubernaculum; in, intestine; is, isthmus; lf, lateral field; mc, metacorpus; nr, nerve ring; ov, ovary; ov, ovary; pa, papilla; pc, procorpus; ph, phasmid; re, rectum; sp, spicule; st, stoma; te, testis; ut, uterus; va, vagina; vu, vulva. Scale bars: A, E=50 µm, B-D, F=20 µm.

**Table 1.** Morphometrics of *Bursilla vernalis*, *Mesorhabditis inarimensis*, and *M. minuta*

Character	<i>Bursilla vernalis</i>		<i>Mesorhabditis inarimensis</i>		<i>Mesorhabditis minuta</i>	
	♀, n=1	♂, n=1	♀, n=2	♂, n=1	♀, n=5	♂, n=2
L	483.5	335.6	475.6±41.1 (446.5-504.6)	449.2	545.5±95.4 (436.8-696.1)	370.4±54.0 (332.2-408.5)
a	19.5	18.3	19.3±0.1 (19.2-19.3)	24.8	17.5±0.7 (16.3-18.3)	16.5±0.1 (16.4-16.5)
b	3.8	3.2	3.7±0.4 (3.4-4.0)	3.4	4.4±0.5 (3.8-5.0)	3.7±0.1 (3.6-3.8)
c	8.0	7.6	8.5±0.9 (7.9-9.2)	31.2	9.2±0.8 (8.3-10.2)	19.6±1.3 (18.7-20.6)
c'	4.5	3.4	3.9±0.3 (3.7-4.1)	1.2	4.4±0.5 (3.9-5.3)	1.2±0.2 (1.1-1.3)
v	73.4	—	73.2±1.4 (72.2-74.2)	—	75.2±0.9 (74.1-76.2)	—
G or T	29.3	43.6	25.6±2.9 (23.6-27.6)	49.1	31.2±4.5 (27.2-37.9)	47.2±5.7 (43.2-51.3)
Body diameter	24.8	18.4	24.7±2.2 (23.1-26.3)	18.1	31.2±5.7 (24.7-39.4)	22.5±3.2 (20.2-24.7)
Pharynx length	128.1	105.9	128.6±3.0 (126.5-130.7)	133.9	122.8±9.5 (115.0-139.3)	100.0±11.0 (92.2-107.7)
Tail length	60.4	43.9	55.9±1.2 (55.0-56.7)	14.4	59.3±9.4 (52.4-75.5)	18.8±1.5 (17.8-19.9)
Anal body diameter	13.3	13.1	14.3±0.7 (13.7-14.8)	12.1	13.4±0.9 (12.3-14.4)	16.1±3.7 (13.5-18.8)
Lip region diameter	8.7	6.4	7.9±0.9 (7.3-8.6)	6.2	8.2±0.5 (7.6-8.9)	6.9±0.5 (6.6-7.2)
Stoma	16.0	13.8	14.9±0.3 (14.7-15.1)	16.2	15.7±0.6 (14.8-16.6)	13.5±1.3 (12.6-14.5)
Stoma diameter	6.0	2.4	3.4±0.4 (3.1-3.7)	2.1	3.6±0.3 (3.1-3.9)	2.8±0.0 (2.8-2.9)
Stoma/lip region diameter	1.8	2.2	1.9±0.2 (1.7-2.1)	2.6	1.9±0.1 (1.8-1.9)	2.0±0.1 (1.9-2.0)
Stoma/stoma diameter	2.7	5.8	4.4±0.6 (4.0-4.8)	7.6	4.4±0.4 (4.0-5.0)	4.8±0.4 (4.5-5.0)
Corpus	50.8	40.7	53.8±0.4 (53.5-54.1)	55.5	49.5±6.8 (43.2-60.6)	38.4±2.5 (36.6-40.2)
Procorpus	36.3	28.6	35.7±1.1 (34.9-36.5)	38.5	35.0±3.9 (31.6-41.2)	28.2±1.6 (27.0-29.3)
Metacorpus	14.5	12.2	18.1±0.7 (17.6-18.6)	16.9	14.5±2.9 (11.6-19.5)	10.3±0.9 (9.6-10.9)
Isthmus	32.2	28.4	30.8±2.9 (28.7-32.8)	38.0	28.4±2.1 (25.3-30.6)	25.8±3.8 (23.1-28.5)
Basal bulb	23.6	17.4	23.3±0.3 (23.0-23.5)	19.3	21.9±1.8 (19.9-24.4)	18.0±2.2 (16.4-19.6)
Basal bulb diameter	16.5	12.3	15.9±2.1 (14.4-17.4)	12.3	16.7±2.0 (14.2-19.0)	13.7±1.5 (12.7-14.8)
Basal bulb length/diameter	1.4	1.4	1.5±0.2 (1.4-1.6)	1.6	1.3±0.1 (1.2-1.4)	1.3±0.0 (1.3-1.3)
Corpus:isthmus ratio	1.6	1.4	1.8±0.2 (1.6-1.9)	1.5	1.7±0.2 (1.5-2.0)	1.5±0.1 (1.4-1.6)
Nerve ring to ant. end	83.6	67.9	79.7±8.9 (73.4-86.0)	84.0	80.8±8.4 (74.6-95.6)	66.9±4.8 (63.5-70.2)
Excretory pore to ant. end	99.8	82.8	95.4±12.8 (86.4-104.5)	93.2	96.4±11.1 (88.1-114.6)	80.6±5.3 (76.9-84.4)
Nerve ring position (% pharynx)	65.2	64.1	62.1±8.4 (56.2-68.0)	62.7	65.7±2.3 (63.1-68.6)	67.0±2.6 (65.2-68.9)
Excretory pore position (% pharynx)	77.9	78.3	74.3±11.7 (66.1-82.6)	69.6	78.3±3.8 (73.3-82.3)	80.9±3.6 (78.3-83.4)
Vulva from ant. end	355.1	—	348.3±37.0 (322.2-374.4)	—	410.4±72.6 (326.1-522.1)	—
Vulva to anus	69.7	—	73.3±7.4 (68.1-78.5)	—	69.8±8.0 (57.5-78.5)	—
Vulva to anus/tail length	1.2	—	1.3±0.2 (1.2-1.4)	—	1.2±0.1 (1.0-1.4)	—
Reproductive tract length	141.5	146.5	122.3±24.3 (105.2-139.5)	220.7	170.9±39.8 (122.1-210.8)	176.4±46.7 (143.4-209.5)
Vagina	7.2	—	7.6±1.5 (6.5-8.7)	—	8.9±1.9 (7.0-11.4)	—
Uterus	47.0	—	68.3±11.1 (60.4-76.1)	—	68.8±21.4 (47.2-97.0)	—
Vagina/body diameter	0.3	—	0.3±0.0 (0.3-0.3)	—	0.3±0.0 (0.3-0.3)	—
Uterus/body diameter	1.9	—	2.8±0.7 (2.3-3.3)	—	2.2±0.4 (1.9-2.9)	—
Spicules	—	17.9	—	47.0	—	22.7±0.1 (22.7-22.8)
Spicules/anal body diameter	—	1.0	—	3.9	—	1.4±0.3 (1.2-1.7)
Spicules/tail length	—	0.4	—	3.3	—	1.2±0.1 (1.1-1.3)

Character	<i>Bursilla vernalis</i>		<i>Mesorhabditis inarimensis</i>		<i>Mesorhabditis minuta</i>	
	♀, n=1	♂, n=1	♀, n=1	♂, n=2	♀, n=1	♂, n=2
Gubernaculum	—	6.8	—	—	21.1	—
Gubernaculum/anal body width	—	0.4	—	—	1.7	—
Spicules/gubernaculum	—	2.6	—	—	2.2	—
Rectum	22.1	—	24.0±0.1 (23.9–24.0)	—	—	23.0±3.3 (19.5–27.6)
Rectum/anal body diameter	1.7	—	1.7±0.1 (1.6–1.7)	—	—	1.7±0.2 (1.5–1.9)
Anus to phasmid	—2.9	—	2.1±1.5 (1.0–3.1)	—	—	0.0±0.7 (−1.0–0.8)
Phasmid position (% tail)	—4.8	—	3.7±2.5 (1.9–5.4)	—	—	−0.1±1.2 (−1.9–1.5)
Lateral field width	5.2	—	6.9±0.5 (6.5–7.2)	—	2.2	4.8±1.0 (3.5–5.6)
Lateral field width/body diameter (%)	20.8	—	27.8±0.4 (27.5–28.1)	—	11.9	15.4±2.8 (12.7–19.7)
Cuticle thickness	0.8	0.7	0.9±0.2 (0.8–1.0)	—	0.8	1.0±0.3 (0.5–1.3)
Annuli width	1.4	1.0	1.7±0.3 (1.5–1.9)	—	1.4	1.3±0.4 (0.7–1.8)

Measurements are in  $\mu\text{m}$  and in the form mean $\pm$ SD (range).

**Table 1.** Continued

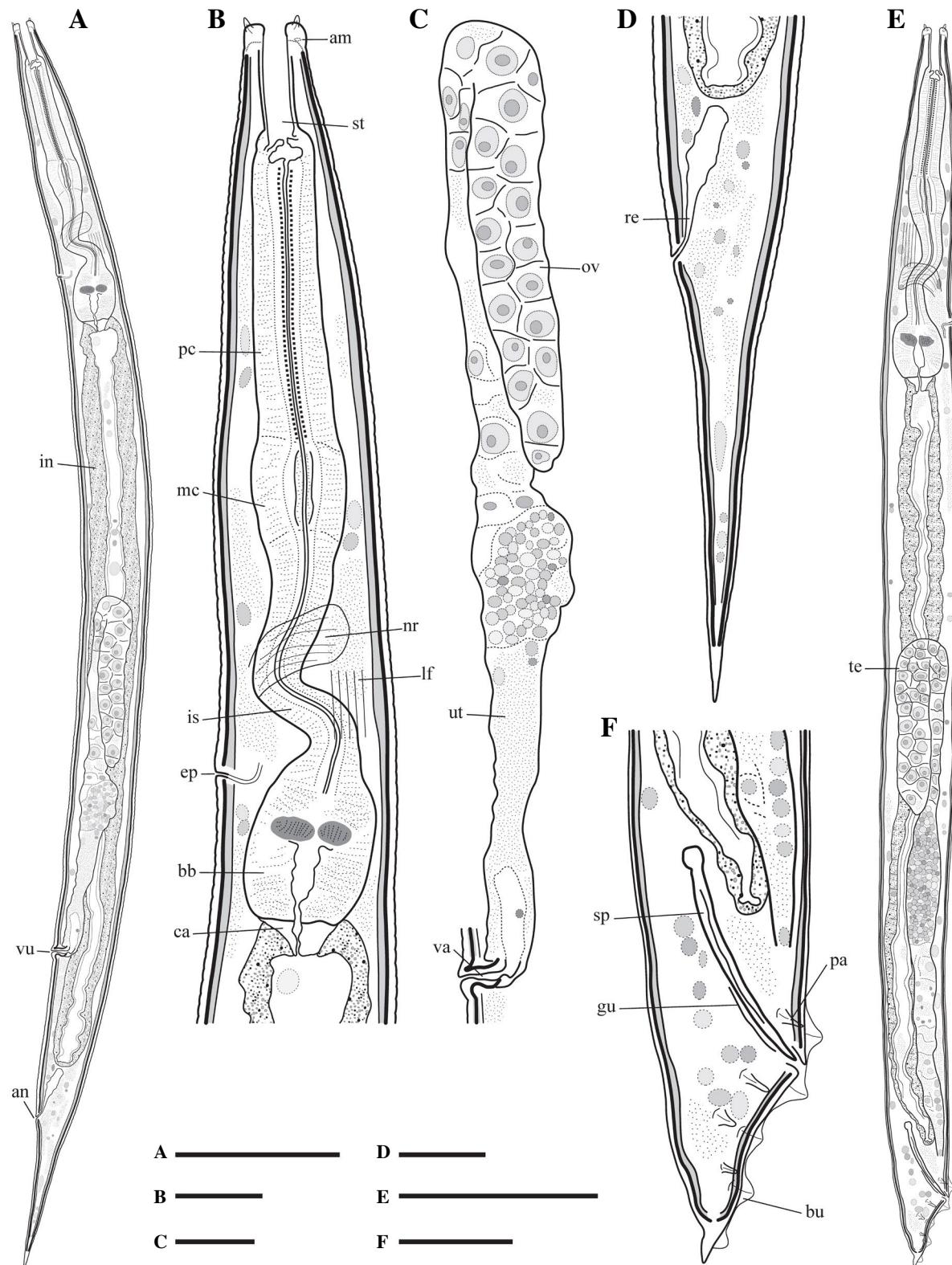
thick at mid-body. Lateral field with five or seven incisures, occupying 12.7–19.7% of width of body at mid-body, fading out at phasmid region, visible under light microscope (Fig. 3B). Lip region 7.6–8.9  $\mu\text{m}$  in diameter, six rounded lips each ending in a setiform papilla (Figs. 3B, 4A). Transversal, oval-shaped amphidial apertures present (Fig. 3B). Stoma typical of the group, 1.8–1.9 times as long as lip region diameter. Cheilostom short, weakly sclerotized. Gymnostom–promesostegostome tubiform; metastegostom bearing well developed glottoid apparatus; telostegostom with rounded rhabdia. Pharynx typical of the group. Corpus 1.5–2.0 times isthmus length; procorpus cylindrical; metacorpus swollen. Isthmus narrower than corpus. Basal bulb ovoid, with well-developed valves; 1.2–1.4 times as long as its width. Cardia conoid, surrounded by intestinal tissue. Nerve ring located at isthmus, at 63.1–68.6% of pharynx length. Excretory pore position at isthmus–basal bulb junction or basal bulb, at 73.3–82.3% of pharynx length. Deirids inconspicuous. Reproductive system monodelphic–prodelphic (Fig. 3C). Vagina length 0.3 times body diameter. Post-uterine sac absent. Uterus length 1.9–2.9 times body diameter; more dilated at distal region, containing spermatozoa. Ovary directed posteriorly, without flexures. Rectum length 1.5–1.9 times the anal body diameter (Fig. 3D). Tail elongated conoid, with pointed terminus (Figs. 3D, 4B). Phasmids located in anus region.

**Male:** General morphology similar to female. Body length 332.2–408.5  $\mu\text{m}$  long (Fig. 3E). Cuticle annuli 1.1–1.5  $\mu\text{m}$  wide and 0.3–0.8  $\mu\text{m}$  thick at mid-body. Lateral field with five incisures, occupying 17.3–24.2% of body diameter at mid-body, inconspicuous at tail region. Lip region 6.6–7.2  $\mu\text{m}$  in diameter. Stoma 1.9–2.0 times as long as lip region diameter. Corpus 1.4–1.6 times isthmus length. Basal bulb 1.3 times as long as its width. Nerve ring located at isthmus, at 65.2–68.9% of pharynx length. Excretory pore position at isthmus–basal bulb junction, at 78.3–83.4% of pharynx length. Genital system monorchic. Testis reflexed dorsad anteriorly. Spicules fused distally, 22.7–22.8  $\mu\text{m}$  long, 1.2–1.7 times the anal body diameter; manubrium rounded; calamus narrower than manubrium (Fig. 3F). Gubernaculum sigmoid. Tail conical, with pointed terminus. Peloderan bursa with nine (2+4+3) pairs of papillae.

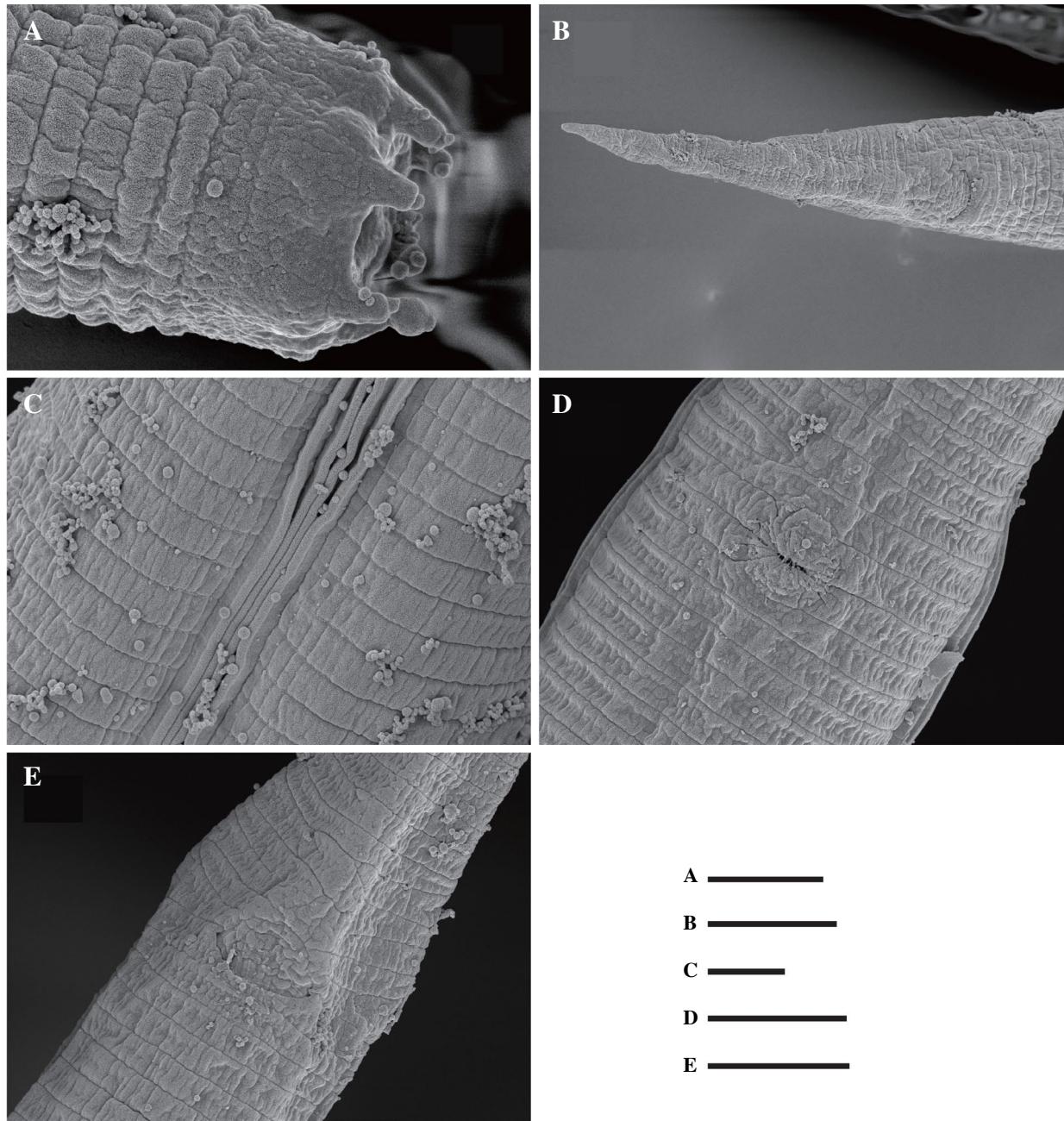
**Distribution.** Greece (Boström, 1991), Pakistan (Tabassum and Shahina, 2003), South Korea (this study), Spain (Abolafia and Peña-Santiago, 2009).

**Habitat.** Soil sample taken from a strawberry farm.

**Remarks.** Morphological characters and measurements of the specimens described here perfectly match the original description of *M. minuta*. In the original description of *M. minuta*, there are five longitudinal incisures present in the lateral field (Boström, 1991). However, Abolafia and Peña-Santiago (2009) suggested seven incisures based on SEM images



**Fig. 3.** *Mesorhabditis minuta* Boström, 1991. A, Entire female; B, Female neck region; C, Female reproductive system; D, Female posterior region; E, Entire male; F, Male posterior region. am, amphid; an, anus; bb, basal bulb; bu, bursa; ca, cardia; ep, excretory pore; gu, gubernaculum; in, intestine; is, isthmus; lf, lateral field; mc, metacorpus; nr, nerve ring; ov, ovary; pa, papilla; pc, procorpus; re, rectum; sp, spicule; st, stoma; te, testis; ut, uterus; va, vagina; vu, vulva. Scale bars: A, E=50 µm, B-D, F=10 µm.



**Fig. 4.** *Mesorhabditis minuta* Boström, 1991 (scanning electron microscopy images). A, Female head region, ventral view; B, Female tail region, ventral view; C, Female lateral field; D, Female vulva; E, Female anus. Scale bars: A, C=2 µm, B=10 µm, D, E=5 µm.

(five incisures based on light microscope observations). In this study, under a light microscope, five incisures were observed from six specimens (Fig. 3B). However, seven incisures were observed from one female. On the other hand, it was difficult to judge whether the lines were real longitudinal incisures or the effect of experimental conditions (Fig. 4C). More sampling from a larger population and studies using SEM will be helpful in understanding the exact nature of this

morphological character and improving the accurate identification of this species.

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